Monitoring Completed Navigation Projects (MCNP) Program

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Funding Source
Operation and Maintenance (O&M)

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Purpose of the MCNP Program

The Advancement of Coastal and Hydraulic Engineering Technology

To determine how well Coastal and Inland Navigation projects are accomplishing their purposes (how well they are resisting attacks by the physical environment)

- **Create more accurate and economical engineering solutions**
- **Strengthen design criteria and methodology**
- **Improve construction practices and cost effectiveness**
- **Enhance Operation and Maintenance techniques**

MCNP program identifies where current technology is inadequate. (Determines where additional research is required.)

Engineer Regulation ER 1110-2-8151

Engineering and Design

MONITORING COMPLETED NAVIGATION PROJECTS

31 July 1997

- **Deep- and Shallow-draft Navigation Projects located in the Coastal Zone, Estuaries, Rivers, Lakes, and Reservoirs**
- **Completed Navigation Projects Operated and Maintained by the Corps of Engineers**

MCNP Program is Field Driven, addressing real-world problems.

Nominations for New Monitoring Projects are solicited from Divisions and Districts by HQ as funding becomes available, per ER 1110-2-8151.

Nominations are Evaluated and Prioritized by CECW (Chief, Navigation Branch; RARG) according to criteria of ER 1110-2-8151.

Structures with Unique Features and/or distinct problems.

Site-specific monitoring is intended to produce Generic results and conclusions applicable on a regional and/or national basis.

Program functions at the pleasure of Chief, Navigation Branch, CECW.

MCNP Monitoring and Periodic Inspections
FY08 Program

Kaumalapau Harbor,
Island of Lanai, HI

Periodic Inspections (around the Nation)

FY08 MCNP Program

1. **Periodic Inspections;** Enterprise Coastal Inventory Database (ECID), Kaumalapau B/W, HI
2. **Kaumalapau Harbor;** CORE-Loc Breakwater Armor Unit Stability, Island of Lanai, Hawaii
3. **Great Lakes Breakwater Armor;** Stone Testing Protocols; Burns, Cleveland, Keweenaw
4. **John T. Myers Locks and Dam;** Lock Wall Armor Deterioration, Ohio River
5. **John Day Lock and Dam;** Hazardous Lock Entrance Navigation Conditions, Columbia River
6. **Montgomery Point Lock and Dam;** Unique Flap Gate Dam and Backwater Effects, White River

Periodic Inspections

Product Delivery Team

Jeff Melby (PI), CHL, ERDC

District Team Members in every district where periodic inspections are performed.

Problem

Lack of long-term structure performance data in a consistent format.

Need to gather, analyze, and archive detailed coastal structure condition, performance, and response data on a relatively small number of structures.

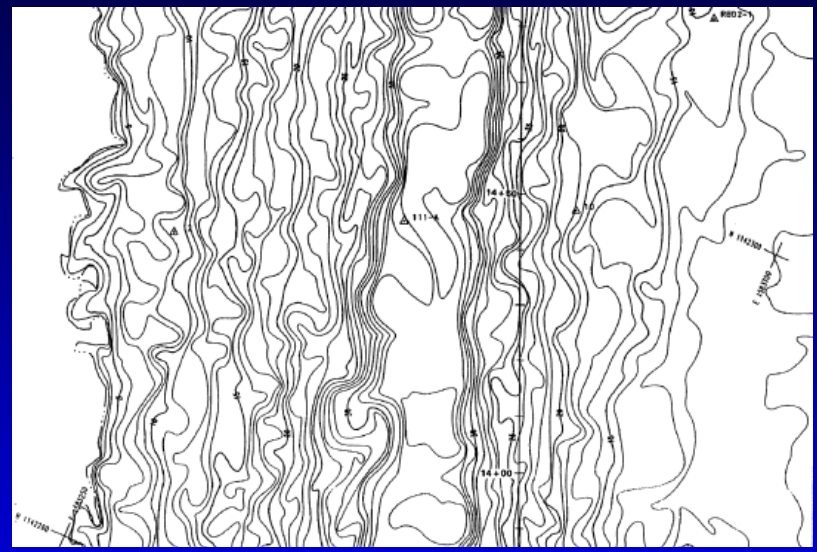
Benefits

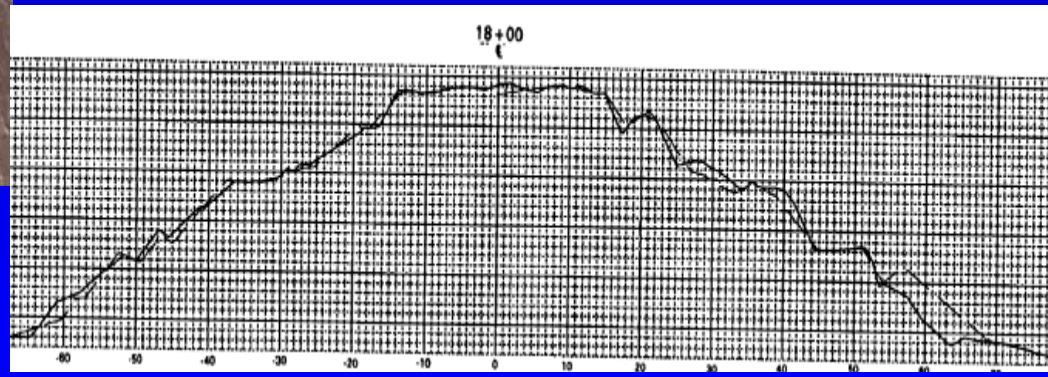
Better performance knowledge translates to better designs and lower O&M costs.

Periodic Inspections

- Coastal Structures
- Work closely with Districts
- Detailed monitoring (SHOALS, lidar, T-Lidar, photogrammetry, walking surveys, photographs)
- Measure stone and concrete armor movement, breakage, subsidence, etc.
- Correlate performance with forcing functions
- Place data into Enterprise Coastal Inventory Database (ECID)

Periodic Inspections





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Example of T-Lidar Precision

Enterprise Coastal Inventory Database (ECID)

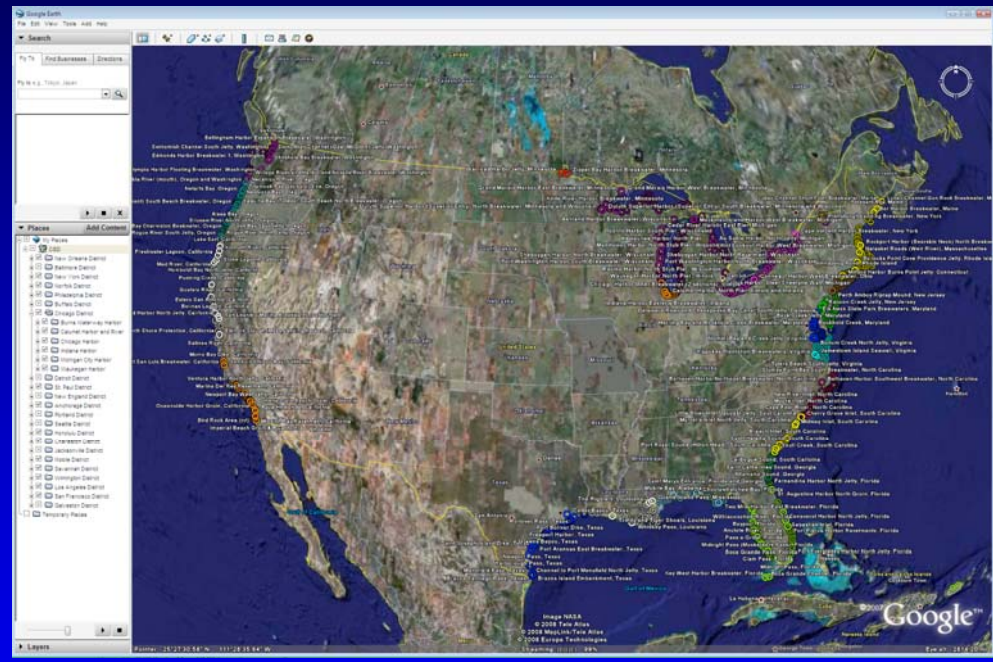
- ECID stores data for over 900 coastal structures and 250 associated inlets, as well as NOAA and NDBC gage data
- Data is accessible using Google Earth interface, or a query website
- Database is an improved and updated version of the Database of Navigation Projects and Structures

ECID Interface

Google Earth

- Interface shows structure and inlet locations, NOAA tide gages, NDBC wave gages

- Info bubbles contain information pertinent to the structure, inlet, or gages, color coded by District



ECID Data Types

Query Site:

- Search by District, Coast, State, Name, or any combination
- Results are distinguished as a structure or inlet
- Download photos, reports, and reach or inlet information

Structures:

- Case history reports (District, REMR, et. al.)
- As-built dimensions and stationing
- Photogrammetry data, Inspection reports, Aerial photos, etc.

Inlets:

- Inlet features
- Dredging reports, Statistics, Tide information

Periodic Inspections FY08

1. Deploy ECID
2. Establish ECID website
3. Digitize previous Periodic Inspection data
4. Update ECID with previous Periodic Inspection data
5. Publish Burns, and Cleveland, Periodic Inspection reports
6. Lidar and multi-beam surveys of Kaumalapau, and Kahului
7. Publish Hilo, Nawiliwili, and Kahului Periodic Inspection reports

Kaumalapau Harbor Breakwater
Island of Lanai, Hawaii

Product Delivery Team
Steve Hughes and Jeff Melby, CHL; Ed O'Neil, GSL: ERDC;
Honolulu District Team Members: Tom Smith and Jessica Podoski (PI)

Problem

Harbor constructed in 1922; Only deepwater port on the island; Services hotel, tourist, and farming industry, and import of food and commercial goods; Breakwater has severely deteriorated over the years.

Non-availability of large quarry stone; Necessary to use manufactured armor units (water depths 70 ft; wave heights 30 ft); 35-ton CORE-Loc armor units (largest ever manufactured) being installed (800 units); Placed over existing broken dolos armor units; Significantly important to understand design, stability, construction, and performance of these CORE-Loc units.

Kaumalapau Harbor Breakwater

Before

After

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800 (35-Ton) CORE-Loc

Specialized Placement Equipment and Methods

Quick Release Hooks

Lifting Frame with Tugger Winches

Double Sling Arrangement

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GPS Positioning of Armor Units

GPS Tolerance = 38cm

Packing Density = 0.62

Random Orientation

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Coastal and Hy

Strength Testing of CORE-Loc

- Loaded with six 50-kip (222kN) hydraulic rams between legs
- Created flexural tensile load to interior saddle of unit, compressive load to exterior
- Load monitored with load cells and strain gages

35-Ton CORE-Loc Test Unit

During Construction

After Construction

Kaumalapau Breakwater FY08

- Underwater inspection using ROV
- T-LiDAR survey of breakwater
- Documented concrete casting temperature and strength
- Calibrated wave model with buoy and wave gage data
- Prepared final report on concrete analysis
- Performed settlement analysis using T-LiDAR
- Updated benchmarks for future District monitoring

Great Lakes Breakwater Armor, Stone Testing Protocols and Durability

Product Delivery Team

Danny Harrelson (PI) and Joe Tom, GSL, ERDC; Mansour Zakikhani, EL, ERDC
District Team Members: Joe Kissane, LRC; Michael Allis, LRE; Jon Kolber, LRB
Ron Erickson, Consultant (formerly LRE District Geologist)

Problem

Specifications for armor stone for breakwaters and jetties include objective criteria from laboratory tests, and subjective criteria based on quarries and stockpiles. Issues relate to stone durability. Variability of quality between and within quarries exceedingly problematic.

ASTM tests presently used were designed for small concrete aggregate and stone many orders of magnitude smaller than stone on breakwaters. These small-scale tests are not appropriate for stone weighing tens of tons.

Present Lab Test Criteria

• Specific Gravity	ASTM C 127
• Absorption	ASTM C 127
• Los Angeles Abrasion	ASTM C 535
• Freeze/Thaw	ASTM D 5312
• Wetting/Drying	ASTM D 5313
• Petrographic Examination	ASTM C 295
• Field Examination	ASTM D 4992

Keweenaw Waterway Structures, MI

Blasted Dolomite

Blasted Limestone

Burns Harbor Breakwater, IN

Cut Limestone

Blasted Granite

Cleveland Harbor Breakwater, OH

Cut Sandstone

Blasted Limestone

Wire-Saw Cut Quarry Operation

Drilled and Blasted Quarry Operation

High-Energy Blasted Dolomite

Study Approach

Evaluate effects of scaling on lab test results using samples of various rock types. Several different sizes of each different stone types from different quarries being cut to the same relative dimensions. Some samples being tested prior to any weathering exposure using existing protocols. Scaling effects being ascertained.

Index Stones being placed on prototype structures to experience weathering effects of wet/dry and freeze/thaw, and large wave attack. Results will be compared to lab tests.

Results will be used to develop guidance and new protocols for armor stone selection with respect to ranking of stone types, excavation methods, and geologic characteristics of material available in a region.

Index Stones include sandstone, limestone, granite, dolomite, and quartzite, and transvestite (concrete).

Numerical modeling to predict degradation over time.

Index Stones for Keweenaw Waterway Structure, MI

Corps LRD Work Barge Placing Index Stones, Keweenaw Waterway Structure, MI

Index Stone on Keweenaw Waterway Structure, MI Lake Superior

Index Stone on Cleveland Harbor Breakwater, OH
Lake Erie

Concrete Armor Units, Ashtabula Harbor Breakwater, OH
Lake Erie

Index Stone on Burns Harbor Breakwater, IN, Lake Michigan

Great Lakes Armor Stone FY08

- Placed 8 armor stones and 4 concrete armor units on Burns Harbor
- Conducted 3 field monitoring site visits to Keweenaw Structures
- Conducted 3 field monitoring site visits to Cleveland Breakwater
- Conducted 1 field monitoring site visit to Burns Harbor
- Continued laboratory testing of Keweenaw Index Stones
- Began laboratory testing of Cleveland Index Stones and concrete armor units
- Continued development of numerical model to predict rate and extent of armor stone degradation
- PI presented peer-reviewed technical paper regarding this MCNP study at International Conference on Coastal Environments

FY08 Laboratory Tests

- 3 sizes of slab-sawed laboratory samples per quarry.
- 12 quarries x 3 sizes per quarry x 5 repetitions = 180 lab samples.
- Laboratory test results will be correlated with field observations corresponding to that particular stone type.
- Guidance documents should be up-dated for construction representatives and geotechnical engineers who prepare design specifications.
- Enhanced ASTM test criteria protocols for armor stone will be deduced. Guidance documents will be prepared for armor stone use around the Great Lakes. Present documents are evolving, and need to be standardized. Update quarry ETL for mapping and geological observations.

Wall Armor System
John T. Myers Locks and Dam, Ohio River

Product Delivery Team

Stan Woodson (PI), GSL, ERDC

District Team Members: Rick Lewis, LRL; Jeff Stamper, MVS; Mike Tarpey, MVR

Problem

Lock wall armor systems experiencing large amount of damage due to large number of vessels passing through locks. Majority of damage includes gouges and spalls in concrete adjacent to armor strips. Many gouges are next to vertical joints. Several locations includes broken armor.

Majority of damage occurs in 1,200-ft lock, due to impact and abrasion by commercial barge traffic that typically use this lock. Broken wall armor is vulnerable to "catching" protruding metal on barges (a special concern for barges that have protection themselves). When armor is worn flat, it is no longer effecting in protecting the surrounding concrete.

John T. Myers Locks and Dam, Ohio River

Wall Armor System Deterioration

Wall Armor System Deterioration

Study Approach

- Design did not provide for wall armor protection at concrete joints, with considerable damage to concrete and armor.
- Ability of this lock to remain fully functional significant to insure continued efficient operation of Ohio River system, a major artery for commercial navigation in the U.S.
- Demonstrate innovative repair techniques at the 600-ft and 1,200-ft locks, and not disrupt navigation traffic through the lock and on Ohio River.
- Continuous monitoring being undertaken to provide prediction indicators of rate and extent of projected deterioration of wall armor system.
- Will indicate time available for development of non-disruptive repair methodology at other locks.

Upstream Entrance Innovative Repair Demonstration 2006

Downstream Entrance Innovative Repair Demonstration 2007

Wall Armor System FY08

- Perform annual damage surveys at selected sections of John T. Myers, and Markland Locks and Dams
- Monitor FY06 and FY07 Demonstration Repairs at John T. Myers Locks and Dam 600-ft lock
- Develop and install Innovative Repair Technique for repair of concrete damage area on the 1,200-ft lock upstream river wall with minimal disruption to navigation

John Day Lock and Dam

Product Delivery Team
Randy McCollom (PI) and Thad Pratt, CHL, ERDC
Portland District Team Members: Kyle McCune and Sean Askelson

Problem

Addition of (a) Spillway Flow Deflectors, and (b) Spill Pattern Generators, and Changed Operations to improve fish passage through the tailrace environment and water quality, adversely impacted Dam's ability to safely meet navigation mission under certain river conditions.

System modifications being investigated to eliminate unsafe navigation situation under certain flow conditions. Lessons learned will be applicable at 7 other similar dams located on the Lower Columbia and Lower Snake Rivers.

John Day Lock and Dam, Columbia River

Study Approach

1. Physical model originally predicted significant flow moving from the spillway toward the powerhouse.
2. Changed flow operations bulked outflow near fish ladder.
3. Comprehensive data set under various flow conditions being acquired to understand impact of flow deflectors and spillway operations on trailrace environment adjacent to navigation lock.
4. Monitoring will establish impact of fish passage changes, and create a data set for improvements to both physical and numerical modeling.

John Day Lock and Dam

John Day Lock and Dam

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John Day Lock and Dam

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John Day Lock and Dam FY06-08 Spill Seasons

1. 2-D ADCP side-looking meters installed (a) on face of powerhouse, (b) along the length of the bays, (c) near downstream end of guard wall, and (d) along north bank approximately 1,000 ft downstream of end of wall.
2. Monitor entrained flow from powerhouse tailrace into spillway, high velocity flow along end of guard wall, and velocities on barge tows along north bank where industry reports problems.
3. Video monitoring records navigation approach, and time-synchronizing all recording devices to determine when hazardous conditions occur.
4. Discharges determined by multiple transits over specific cross sections near downstream island using 3-D ADCP probe mounted on survey boat.
5. Special operations of the dam arranged to examine how dam operation impacts conditions in the lower lock approach.
6. Correlate outflow release rates from spillway and powerhouse.

Montgomery Point Lock and Dam, White River

Product Delivery Team

Howard Park (PI) and Michael Winkler, CHL, ERDC
District Team Member Glen Raible, SWL

- Low water levels on the Mississippi River meant elevations less than that used for establishing lower sill elevations at the next upstream Norrell Lock, resulting in navigation restrictions being imposed (reduced drafts, lengths, and widths; daylight navigation only; escort service). Dredges could not work fast enough to maintain navigation depths.
- Unique dam design with flap gates in the middle of the White River was installed at Montgomery Point. Lock only used at low water on the Mississippi River.
- Navigation alignment difficulties will be monitored. Sedimentation deposits affect flap gate operations. Leakage exists under and between flap gates. Total load on gate operator cylinders will be monitored. Forces on crest gate hinges will be ascertained.

Montgomery Point Lock and Dam, White River

Montgomery Point Lock and Dam, White River

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Montgomery Point Lock and Dam, White River

Montgomery Point Lock and Dam, White River

Montgomery Point Lock and Dam FY08

- Acquired and installed ADCP and video equipment for continuous monitoring
- Collected and reduced bathymetric and ADCP data
- Monitored stone protection grade and cross section alignment
- Monitored downstream stone protection
- Determine instrumentation necessary to monitor forces on the hinges of the flap gates